USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal

Focus Categories: WL, WQL, HYDROL

Keywords: Marshes, Ecosystems, Estuaries, Fish Ecology, Water Quality Monitoring,Geochemistry, Sedimentation, Model Studies

Duration: From April 1, 2000 to March 31, 2001

Federal Funds:

Direct: $23,021 Indirect: $0 Total: $23,021

Non-Federal Funds Pledged:

Direct: $34,066 Indirect: $12,100 Total: $46,166

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Critical Regional Water Problems

The U.S. Geological Survey has identified “Aquatic and Environmental Protection” as one of its research priorities. Specifically, this priority area states “research needs in this

area include studies of wetlands, swamps and marshes, fish and other biota, and the quality of life." The goal of the proposed study is within this research priority area.

The goal of the proposed project is to study the ecological and geomorphological effects caused by the reduction in length of dirt causeways (accompanying bridge replacement) over a tidal waterway (Cowan Creek) and marsh in Beaufort County, South Carolina. Specific objectives to accomplish the stated goal include: 1) studying the effects of the bridge/causeway changes on tidal- and wind-induced circulation through Cowan Creek and the resulting geomorphological changes in the creek and adjacent tidal marshes; 2) evaluating the change in the nektonic community in the creek and tidal marshes in terms of species composition, density, and size distributions; 3) determining whether the percentage of parasitized grass shrimp changes after the changes to the causeways; 4) monitoring the benthic meiofaunal community in the area by collecting sediment cores; and 5) monitoring several surface water quality parameters to allow an assessment of changes associated with the altered hydraulics in Cowan Creek.

Based on previous research, the following changes are predicted to occur in Cowan Creek and the adjacent marshes after completion of the new bridge: 1) increases in water flow and sediment transport rates; 2) change in sediment composition; 3) change in marsh geomorphology and size (i.e., surface area); 4) change in habitat utilization by nekton; and 5) change in various water quality parameters. It is also anticipated that the increase in bridge deck elevation and length, and the potential increase in water depth under the bridge will make this creek a viable transportation route between Port Royal and St. Helena Sounds, thus restoring it to its historic importance. These changes would also enhance recreational usage and enable fisherman to catch the species known to exist there at present (Curran, unpub. data). Some of this work will be directly comparable to the extensive survey conducted in a similar habitat in northern South Carolina (Ogburn *et al*. 1988). Our study will result in a better understanding of how causeways alter flow in tidal creeks and the concomitant change in sediment transport, water quality, sediment composition of marsh habitat, and nekton utilization of estuarine habitats.

Nature, Scope, and Objectives of the Research

Beaufort County, which consists almost entirely of low-lying barrier islands, is one of the fastest growing counties in the country. With the increase in human population and concomitant coastal development, roads are being widened, new bridges are being constructed, and existing bridges are being replaced. In particular, the Route 21 bridge over Cowan Creek, near Beaufort, South Carolina is going to be replaced within the next two years. Construction of bridges over wide inland waterways, such as Cowan Creek, have historically involved the construction of dirt causeways (i.e., elongated highway embankments) to reduce the length, and therefore the cost of the bridge.

Causeways have been shown to reduce the circulation through waterways in that they act as restrictions to flow, and thus greatly decrease the hydraulic efficiency of the waterway (Lee *et al.* 1994). The reduced flow often results in the deposition of sediments and organic detritus, which, over time, leads to the formation of marshes. For example, the

tidal marshes adjacent to Cowan Creek are approximately 2,000 ft wide. Historic French and English nautical charts (circa 1780) show that the width of the waterway has been reduced from 2,000 ft to its present day width of approximately 80 ft. This proposal raises an interesting philosophical argument. Is the "restoration" of this estuary to its historical state desirable, if this indeed does occur, if it will most likely result in the reduction of marsh habitat and perhaps alter the community of organisms that utilize the marsh and adjacent estuarine habitat?

Cowan Creek is a tidal waterway that connects St. Helena Sound and the Beaufort River. The mean tidal range at the Route 21 bridge is 7.1 ft, whereas the spring tidal range varies from 9.5 to 11 ft. The South Carolina Department of Transportation (SCDOT) is initiating work that will eventually reduce the lengths of the two dirt embankments across Cowan Creek by 425 percent and replace the existing 120 ft bridge with a new 510 ft bridge. Our proposed study will document the changes in the flow regime, tidal marsh geomorphology, utilization of marsh habitat by nekton, and water quality that will occur with the replacement of the existing bridge over Cowan Creek. This study would be unique because it would address the impact of the removal (not addition) of a man-made structure (i.e., dirt causeways). We predict that the following changes will occur in Cowan Creek and the adjacent marshes after completion of the bridge replacement: 1) an increase in water flow and sediment transport rates; 2) a change in sediment composition; 3) a change in marsh geomorphology and size (i.e., surface area); 4) a change in habitat utilization by nekton; and 5) a change in various water quality parameters. It is also anticipated that the increase in bridge deck elevation and potential increase in water depth will make this creek a viable transportation route between Port Royal and St. Helena Sounds, thus restoring it to its historic importance. These changes would also enhance recreational usage and enable fisherman to catch the species known to exist there at present (Curran, in prep.). Some of this work will be directly comparable to the extensive survey conducted in a similar habitat in northern South Carolina (Ogburn *et al*. 1988).

Our request to continue this research this summer is crucial because work on bridge replacement is scheduled to be completed in 2000. The South Carolina Sea Grant Consortium (SCSGC) has approved funding ($7,000) to assist in the pre-construction study in 1999. The on-going two-year study is a continuation of the work previously funded by the South Carolina Water Resources Center. At present, no obvious changes to the marsh or Cowan Creek have occurred (see attached Progress Report). The proposed research is part of a broader-scale interest in the estuaries of Beaufort County. We will be able to integrate the results of the proposed study with those collected from our study sites on Pritchards Island. In particular, we are currently monitoring the changes in abundance of juvenile fishes in two connected marsh creeks. Additionally at this site, a study of larval and juvenile nekton utilization of a developing overwash impacted barrier island marsh (containing sandy sediments) with an adjacent established marsh (containing natural mud sediments) indicated that juvenile nekton use of marsh habitat at similar tidal elevations is markedly different (Cross, in prep). These differences may be related to differences in benthic metazoan food resources available in the different sediment types (Cross, in prep). Other information concerning the importance of sediment associated factors to nekton utilization of intertidal marshes may be found from

studies of artificially created marshes in the early stages of development which contain sediments with a large sand component. Comparisons of these marshes to established, natural marshes have demonstrated reduced densities of juvenile *Fundulus* and harpacticoid copepods in the created marshes (Moy and Levin 1991), both of which are important food sources. Numbers of commercial species may also decrease. We anticipate a change in sediment composition over time at Cowan Creek due to altered hydrology and system morphology. Thus, accumulating evidence suggests that differences in sediment composition can alter nekton utilization of marsh habitats and benthic metazoan food resources upon which they feed. In summary, this research will result in a better understanding of how causeways alter flow in tidal creeks and the concomitant change in sediment transport, water quality, availability and sediment composition of marsh habitat, and nekton utilization of estuarine habitats.

The goal of this project is to continue a multi-year study of the ecological and morphological effects caused by the reduction in length of the Highway 21 dirt causeways over Cowan Creek. Specific objectives to accomplish the stated goal of the herein proposed study are:

a. to study the effects of the bridge/causeway changes on tidal- and wind-induced circulation through Cowan Creek and the resulting morphologic changes in the creek and adjacent tidal marshes. Changes in morphology will be determined by a GIS using pre- and post-construction surveys.

b. to evaluate the change in the nektonic community in the creek and tidal marshes in terms of species composition and density;

c. to determine whether the percentage of parasitized grass shrimp changes after removal of the causeways;

d. to continue monitoring the benthic meiofaunal community in the area by collecting sediment cores;

e. to monitor several surface water quality parameters to allow an assessment of changes associated with altered hydrology. Parameters measured will include: concentrations of ammonia, reactive phosphorus, and dissolved oxygen, turbidity, suspended sediments, suspended particulate organic matter, temperature and salinity.

Methods, Procedures, and Facilities

See attachment for progress report. The methodology proposed to accomplish the stated objectives are described next. The first three tasks are components of the remaining ones.

a. Measure the tides in the Beaufort River and St. Helena Sound at the entrances to Cowan Creek -The USGS has installed a stage and conductance recorder in the Beaufort River across from the entrance to

Cowan Creek as a component of a study to determine Total Daily Maximum Loads (TMDLs) in the Beaufort River. The Beaufort-Jasper Water Authority is funding this study. Thus, we will have access to these data. Another stage and conductance recorder, to be paid for using funds from the SCSGC project, was installed by the USGS in St. Helena Sound near the entrance to Cowan Creek.

b. Perform a limited survey of the creek and marsh to determine the bathymetry and geometry of this system – Using survey equipment (either a survey grade GPS unit or a total station), the elevations of at least 50 locations throughout the marsh along Cowan Creek will be surveyed to determine the variation in the marsh surface elevation. In addition, the bathymetry of the creek will be determined using a boat and fathometer.

c. Monitor the changes in the morphology of the creek and marsh, particularly in proximity to the bridge, during and following construction of the new bridge – This will be performed bi-monthly using the previously described surveying techniques.

d. Model the circulation and sediment transport in Cowan Creek using the HSCTM-2D hydrodynamic and sediment transport model (Hayter *et al*. 1998). The purpose of this modeling effort is to predict the increase in hydraulic efficiency of the creek and the decrease in marsh surface area that we propose will occur after bridge replacement. The measured tides and conductances at the two entrances of Cowan Creek, along with the measured wind field at the nearby University of South Carolina Beaufort campus and the U.S. Marine Corp Base on Parris Island, will be used as the boundary conditions to predict the tide- and wind-induced circulation through this waterway system. Current measurements at several locations throughout the creek over the course of a spring tidal cycle will be used to calibrate the hydrodynamic model. In addition, the predicted change in tide- and wind-induced circulation will be correlated to the monitored change in marine species composition and density to determine the effect of the current regime on the marsh and creek habitat.

e. Utilize the GIS capabilities that will be available at Spring Island (through collaboration with the Low Country Institute) and USC Beaufort to make our data available over the Web.

f. Evaluate the change in sediment composition in the creek system and on the marsh by two different methods. Sediment cores will be collected at a variety of locations and transported to the lab, dried, weighed and sorted through a series of sieves to determine % sediment fraction. Additionally, the fractions of sand, silt, and clay will be determined in sediments using the American Society for Testing and Materials procedure D422. Organic matter content will also be determined by combustion.

g. Evaluate changes in the sediment deposition rates and composition of transported sediments in the creek system and marsh by deploying sediment traps at selected locations where changes in hydrological flow rate are expected to occur. These sediment samples will be treated as described above in the previous description (f).

h. Perform seining to evaluate the change in species composition and density. We will use pit traps on the intertidal marsh to determine larval and nekton use of these habitats. A 10-ft seine net will be used at low tide to assess species composition, and the numbers and sizes of fishes. Length frequency distributions will be constructed in order to identify the size classes that are most abundant in this area. Based on 1998 data (Curran, in prep.) we anticipate a seasonal change in species composition and size.

i. Determine the parasitism rate of shrimp by collecting and measuring individuals in three replicate seine hauls and counting the number of parasitized and unparasitized shrimp.

j. Survey the number of major meiofaunal groups by collecting sediment cores in a variety of areas of the creek bed. We will sample the top three centimeters of sediment using a 2-cm syringe. Two replicate cores will be taken. Samples will be preserved and stained in a 15% buffered formalin/rose bengal solution for examination under stereomicroscope at 20X. Animals will be enumerated and categorized into the taxonomic groups: nematodes, copepods, ostracods, polychaetes, and oligochaetes.

k. Various water quality parameters of surface water will be determined. Ammonia and reactive phosphorus concentrations will be measured with a spectrophotometer. Turbidity will be measured on site with a nephelometer. Particulate organic matter will be measured following filtration and combustion on glass fiber filters. Dissolved oxygen will be measured on site with a portable dissolved oxygen meter. Salinity will be determined with a refractometer. Replicate samples for the above water quality parameters will be collected from the study site every other week from May through August and every other month from September through April. Samples will be filtered, transported to the lab at USCB, and analyzed on the same day of collection or preserved for analysis if samples cannot be analyzed on the same day. Periodically, samples will be collected from water draining the marshes and will be compared with flooding water samples.

Related Research Activities

To the best of the investigators' knowledge, this study will be unique because it will address the impact of the removal (not addition) of a man-made structure (i.e., dirt

causeways) on estuarine waterways and adjacent wetlands. Related research previously conducted by the investigators at the proposed study site includes:

a. We have already completed the first year of our study. We have therefore assessed the state of the marsh system before any alterations have occurred (see attached Progress Report).

b. The PIs have already constructed a 200-m long elevated walkway within 500 m of the bridge to enable access to the marsh with minimal disturbance in the area most likely to be affected by the altered hydrodynamics. Members of the local community assisted in the construction because of their continued interest in our current baseline study of the marsh.

c. Drs. Curran and Cross have already approached the Beaufort County Council to obtain their approval for the study of this marsh system impacted by coastal development. Beaufort County is one of the first counties in South Carolina to develop a comprehensive coastal land use plan. We have strong support from the local politicians, concerned citizens whom have allowed us access to the marsh through their property, and the Beaufort Marine Institute which has volunteered use of their teenagers to help sample and build necessary structures.

d. Drs. Curran, Cross and Hayter conducted a reconnaissance level study of Cowan Creek during a new moon spring tide on July 23 and 24, 1998. This study included measuring currents at several locations in Cowan Creek.

e. Dr. Curran has conducted additional weekly sampling in 1998 to determine the species composition and size distribution of fishes using this area. R. Cross and M.C. Curran have also evaluated the composition of the major meiofauna taxa in undisturbed sediments as well as those disturbed by the construction of sting ray pits. Additionally, in 1998, M.C. Curran has noted the degree of parasitism by an isopod crustacean on grass shrimp, a major food source of fishes.

f. Dr. Cross has conducted baseline studies of marsh utilization by larval and juvenile nekton.

g. Dr. Cross has conducted baseline water quality and sediment studies that involved three undergraduate students and one student from the Governor’s School of Math and Science. In addition to the baseline studies several experiments were conducted at the study site including small scale nutrient dynamics in ray feeding pits, effects of fiddler crab feeding activities on benthic meiobenthos and microalgae, and characterization of sediments at the study site.

References

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